CHEMISTRY

Beyond the Classroom

The Aurora

What awesome sights are these northern lights, whatever be their meaning
As they dance and prance their ritual dance, shifting, fading, gleaming, . . .

—Robert H. Eather in "Majestic Lights,"
1980, American Geophysical Union

Far and away the most spectacular atmospheric phenomenon is the light display called the aurora (*aurora borealis* or "northern lights" in the northern hemisphere; *aurora australis* in the southern hemisphere). Still pictures (Figure A) can never capture their full glory; the rays of light pulsate constantly, alternately waxing and waning. Usually the aurora is brightly colored, most often red, green, or blue. The lights can appear as high as 1000 km in the night sky; their greatest intensity is typically found 100 to 150 km above Earth's surface.

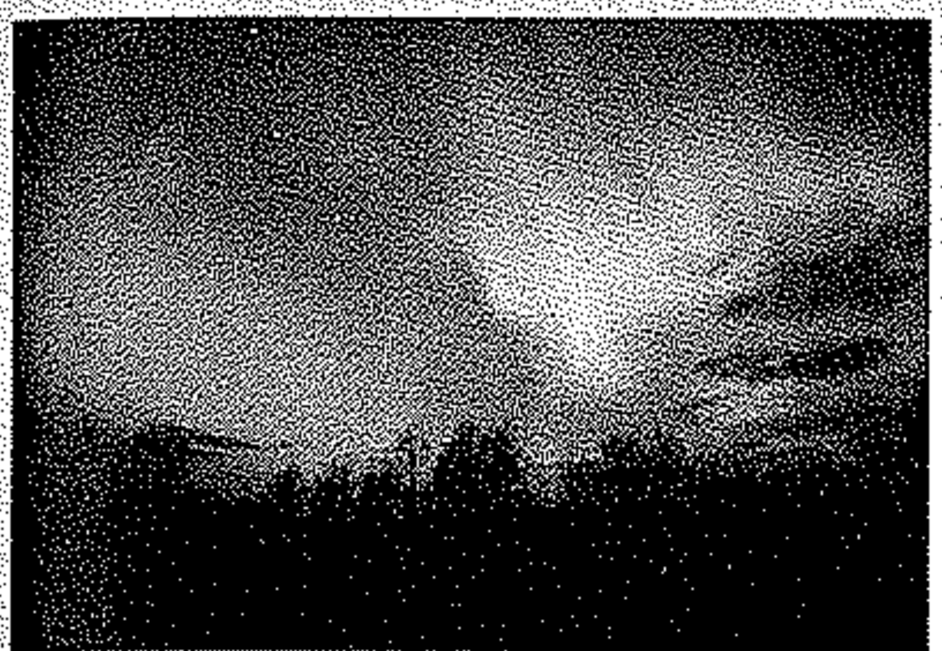

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FIGURE A
The aurora borealis, as seen from Prince Edward Island, Canada.

The aurora borealis is concentrated in an oval-shaped area near Earth's north magnetic pole. Occasionally it becomes visible much farther south, which explains why it was studied extensively by Benjamin Franklin in the United States and John Dalton in England. If you've never seen an aurora (most people haven't), you could travel to Barrow, Alaska, where there is a display every night of the year. (Take a sweater along, because the average nighttime temperature in Barrow is somewhere below −20°C). If you live in New York City, you have about 1 chance in 20 of seeing the aurora on a clear, moonless night when there is a power outage. Rural New England (e.g., Storrs, Connecticut) where the bright lights are dimmer would be a better choice (for seeing the aurora, that is). To further improve your chances, note that northern lights are seen most often—

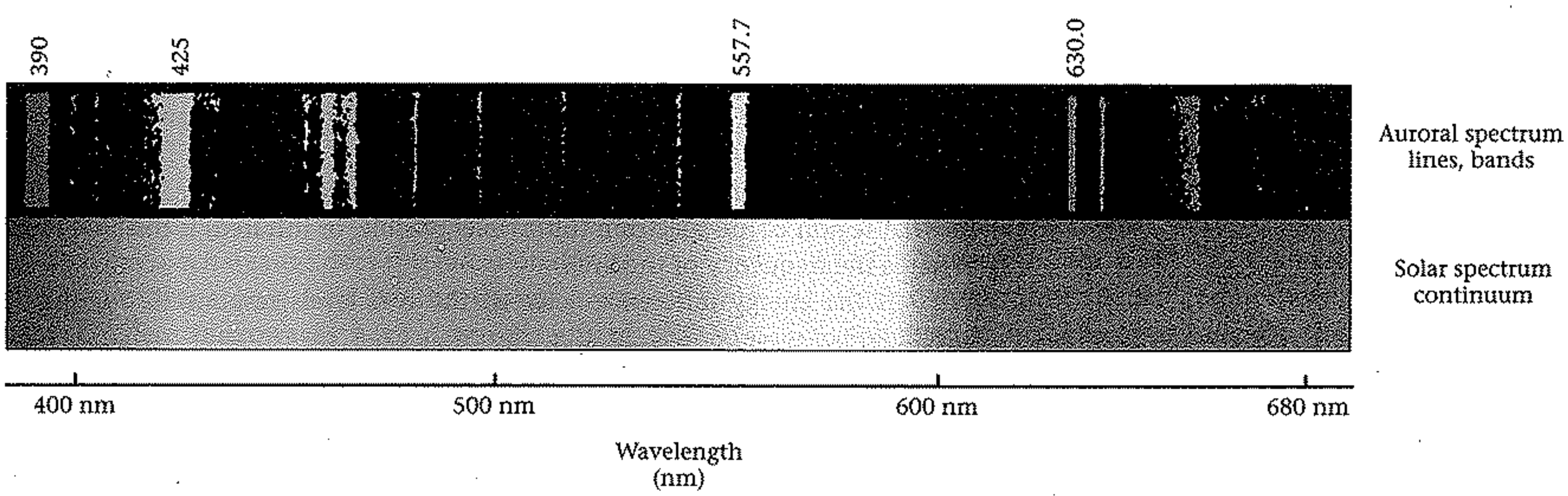
- around the equinoxes in March and September, between 9 P.M. and midnight.
- a couple of days after a major solar disturbance ("Sun spots").

Hundreds of years ago, native Americans interpreted the aurora to be the spirits of the dead fighting one another in the sky; the red glow was supposed to reflect the blood spilled in these conflicts. Today, scientists have a more mundane explanation. We attribute the colors of the aurora to the visible spectrum produced when electrons and protons from the Sun interact with and energize atoms, molecules, and ions in the upper atmosphere. Two types of spectra are observed (Figure B)—

- ***line spectra,*** very similar to those discussed in this chapter. These result from electron transitions in atoms, mostly O and N, or to a lesser extent in monatomic ions such as O^+ or N^+. The two brightest lines in the auroral spectrum, at 557.7 nm (green) and 630.0 nm (red), are both due to atomic oxygen.
- ***band spectra,*** where the emission of light is spread over a range of perhaps 10 to 100 nm in a particular region of the spectrum. These arise from electron transitions in molecules (O_2, N_2) or molecular ions (O_2^+, N_2^+). The blue color sometimes seen in auroras is associated with spectral bands around 400 nm in N_2^+ and N_2.

Curiously, neither of the two lines referred to above, at 557.7 nm and 630.0 nm, is observed in the normal spectrum of oxygen, as obtained with laboratory instruments at Earth's surface. There, excited oxygen atoms lose their energy, not by emission of light but by collision with other atoms. In the upper atmosphere, atoms are very far apart (the total pressure at 100 km is only 10^{-8} atm). As a result, they seldom collide with one another, so excited oxygen atoms stay around long enough to emit visible light.

FIGURE B
Colors in the aurora. The red and green colors characteristic of the aurora are due to lines in the spectrum of atomic oxygen at 630.0 nm and 557.7 nm.



"Majestic Lights" by Robert H. Eather, American Geophysical Union